

Anesthesiology Intraoperative Laboratory Usage

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What Does An Anesthesiologist Do?

- The ultimate goal is to provide a patient with a pain free surgical experience while creating optimal operating conditions for the surgeon and keeping the patient medically stable.
- On a more basic level, the mandate is to ensure oxygen delivery to all tissues at all times.
- To this end, the anesthesia provider must understand:
 - The complete medical history
 - The pharmacological history
 - Physiological changes caused by underlying disease processes
 - All available laboratory information
 - Expectable physiological changes caused by the operative procedure

Preoperative Testing – Are There Standards?

- Notable authorities in anesthesiology warn against routine blanket testing
- Medicolegal implications of un-noticed results possibly dangerous
- Unnecessary expense
- Repetitive testing source of “hospital acquired anemia”

But:

- Case cancellation due to presumed indispensable results
- Medicolegal ramifications of “negligent” failure to obtain tests
- “There cannot be too much information” attitude

Result: Routine over-testing

The Anesthetic Plan

- Based on the integration of patient health factors, surgical physiological impact and patient and surgeon preference, an anesthetic plan is developed.
- Anesthetic techniques may vary from mere sedation, via regional techniques (peripheral nerve blocks, spinal or epidural anesthesia) to general anesthesia.
- Laboratory testing may play a significant role in the preoperative evaluation and ultimately the anesthetic plan.
- Depending on many factors, a satisfactory evaluation may be in place the day of surgery, or last minute studies may become necessary.
- By and large the extent to which a patient is tested is heavily dependent on provider preference and much less on hard and fast guidelines.

Brief Overview: Lab and Anesthetic Technique

- Coagulation status, platelet function, leukocytosis, septicemia: Neuraxial anesthesia vs general anesthesia.
- Measures of Glucose control: Deep sedation or laryngeal mask airway vs general anesthesia with endotracheal tube.
- Cardiac injury profile, troponin, measures of heart failure (NT proBNP): Choice of pharmacological agents and invasive monitoring.

Brief Overview: Lab and Anesthetic Technique

- Baseline hematocrit: use of "Acute Normovolemic Hemodilution"; definition of the blood loss threshold for transfusion; potential delay of operation to investigate unexplained anemia; choice of type and size of access; possible invasive monitoring.
- Liver function tests, measures of hepatic synthetic function: Definition of anesthetic risk; change of anesthetic management; potential need for preoperative transfusion therapy.
- Electrolytes: Potential restriction of pharmacological agents.
- Renal function tests: Fluid management and choice of solutions
- Endocrinopathies: Adequacy of medical control.

Truisms for Perioperative Testing:

Rule # 1: The closer to surgery, the more “stat” a test becomes.

Rule # 2: Intraoperative tests are always extremely “stat”.

Rule # 3: There is an inverse relationship between sample volume and patient well being.

Rule # 4: Extremely abnormal results may well be caused by sampling errors (repeat testing advised).

Rule # 5: Out-of-context results may be due to mislabeling (happens all too often)

The Expanding Role of Bedside Testing

- “Point of Care Testing” is increasingly used in operating rooms
- Large variety of devices available:
- Blood gas analyzers (with and without electrolytes, H & H)
- I-Stat (Large variety of measurable parameters)
- Electrolytes
- Glucose
- H & H
- Activated clotting time
- PT
- Thrombelastography
- Available but not commonly used: Bacterial screening

Main Laboratory vs POCT

Main Laboratory

- **Pros:**
 - Better QA, result consistency, operator training.
 - Results usually entered immediately into hospital information system.
 - Failsafe procedures for abnormal results.
 - No immediate cost to the OR
 - In general: cheaper
- **Cons:**
 - Time lag through specimen transport
 - Lost or dropped specimen
 - Specimen preparation time
 - "Time in Cue"
 - Result entry (if manual)

Main Laboratory vs POCT

POCT

- **Pros:**
 - Direct specimen to machine
 - Very short turn-around-time
 - Immediately repeatable if result unexpected
 - No lag-time phenomenology (lactate, pCO₂)
- **Cons:**
 - Sample mishandling
 - Improper device operation
 - Poor device QC
 - Poor result information dissemination
 - Inconsistent billing (poor coverage of device expenses)
 - Confusion in case of device break-down

Tests in the Spotlight

➤ The Basics:

- Electrolytes

Information sought:

- Na (SIADH, hyponatremia vs hypernatremia)
 - K (K as limiter to the use of Succinyl Choline). Hypokalemia as cause for hypotonia and hypotension. Na mostly for CNS function.
 - Bicarbonate (marker of shock)
 - Renal Function
 - Magnesium (cardiology)
 - Ca, PO₄ (muscle, cardiac function).
- Intraoperatively followed with use of diuretics, massive transfusion or large scale fluid shifts (burns, septic shock).

Tests in the Spotlight

- CBC

- Baseline Hb, HCT
- Presence of infection (WBC)
- Adequacy of platelet count
- Trending (ongoing hemorrhage, course of infectious process, coagulation status)
- Previously undiagnosed disease process (unexplained anemia, leukocytosis, thrombocytopenia)
- Grading of severity of pulmonary disease (polycythemia)

Tests in the Spotlight

- Coags
 - Usually in the setting of organ function compromise
 - Scanning for adequate hepatic synthetic function (PT)
 - Follow-up on PT normalization in chronically anticoagulated patients (warfarin) or acutely anticoagulated (heparin – PTT) patients
 - Assessment of consumptive coagulopathies (ongoing hemorrhage)
 - Detection of possible hereditary coagulation disturbances (hemophilia)
 - Often in conjunction with platelet function tests
 - Nowadays expanded by anti-Xa titers

Tests in the Spotlight

- Liver function tests
 - Only useful to anesthesiologists as trending tool (acute hepatitis)
 - May determine surgical procedure (as in intraoperative cholangiogram during cholecystectomies if elevated LFTs suggest biliary obstruction)
 - Takes back seat to synthetic and metabolic liver function in the acute setting (synthetic: Albumin, PT; metabolic: Lactate)
 - Coincidental, severe elevations of LFTs will lead to cancellation of non-emergent surgery to allow for cause investigation.

Tests in the Spotlight

- Endocrinopathies:
 - TFTs: Spot check of replacement therapy; hypothyroidism risk increases with age; r/o hyperthyroidism if new onset cardiac arrhythmias
 - If elevated TSH: FT4

 - Diabetic control (Hb A1C)

 - Rarely adrenal function assays

Tests in the Spotlight

- Cardiac enzymes:
 - High risk (vascular) patients frequently present with equivocal symptoms
 - Recent EKG changes
 - Cardiac contusion

 - In patients with manifest coronary disease and CHF hx:
 - NT- proBNP allows for a status spot check (not useful as trending tool)

Tests in the Spotlight

- aBg
 - Baseline in severe lung disease
 - Evaluation of circulatory adequacy (vs shock)
 - Evaluation of pulmonary status in intubated patients
 - Acid base balance
 - Determination of dead space ventilation ($p\text{CO}_2$ vs ETCO_2)
 - Extubation criteria
 - In the POCT setting obtained in combination with basic electrolytes, HB (co-oximetry), lactate and Chloride
 - Following ionized Ca^{++} in massive transfusion

What Procedures Typically Require Intraoperative Laboratory Testing?

- Patient factors:
 - Baseline disturbances (diabetes, anemia, coagulopathies, organ dysfunction)
 - High risk situations
 - Shock or inadequate perfusion
 - Monitoring of therapeutic progress
- Surgical factors
 - Volume shifts
 - Direct manipulation of organs
 - Protracted procedures
 - Major cardiovascular interventions
 - Major neurosurgical procedures

Informational Contents of ASA Monitors

➤ Mandatory ASA monitors:

Non-Invasive BP, EKG, Pulse Oximetry, Temperature, (ETCO₂)

- ✓ General impression of hemodynamics
 - Heart rate and BP suggest state of vasomotor tone and blood viscosity
 - Anesthetic interventions cause predictable changes
 - Adequacy of resuscitation: Clinical observations (blood loss) vs. therapeutic interventions
- ✓ Uptake and transport of oxygen
- ✓ Temperature related changes (decreased vascular resistance with sepsis/fever, increased viscosity with hypothermia)

Limitations of Non-Invasive Monitoring

➔ These parameters allow empirical prediction of physiological status but offer no insight on:

- Hb / Hct (one company has produced a pulse oximeter measuring Hb)
- pO₂
- pCO₂
- Acid base balance
- Electrolytes
- Coagulation

Clinical Examples Case 1

- ❑ Patient A: Fractured hip and waited 3 days for opening in the OR schedule. Baseline labs are normal, WBC 12.2, Hct is 35% and vitals are stable, temp 38^o °C.
- ❑ Q 1: What type of anesthesia?
- ❑ Considerations: Bacteremic picture suggests avoidance of regional anesthetic

- Following induction of anesthesia there are hemodynamic changes:
- BP 90/45, HR 110
- Administration of 500 cc crystalloid improves BP, not HR
- During the operation, blood pools on drapes and floor, precise estimate of blood loss not possible, BP remains stable ⇒ Stat Hb/Hct: 9.8/29%

Case 1 Continued

- Question 2: Is the patient adequately resuscitated?
 - Question 3: What caused the initial drop in BP?
- Laboratory testing can provide better insight than monitoring alone:
- ➔ aBg: pH, HCO₃⁻, BE, Lactate: Adequacy of systemic perfusion
 - ➔ If normal:
 - ➔ BP likely due to low grade bacteremia caused by atelectasis (wbc)
 - ➔ If abnormal: “normal” H&H due to acute volume loss, underresuscitation. Transfusion and more aggressive volume replacement likely necessary
 - ➔ Cardiac factors? Perioperative MI? (CIP)
 - ➔ Pulmonary embolism? (D-Dimers)

Case 2

- ❑ 67 yo M presenting for suspicion of perforated ulcer. Absolute surgical emergency \Rightarrow minimal work-up, immediate transport to OR.
- ❑ Hx of heavy ETOH, Hep C; Baseline labs suggestive of metabolic acidosis ($\text{HCO}_3^- = 15$), electrolytes, H&H are wnl, platelets 98K, INR= 1.4
 - Induction of general anesthesia (drugs suitable for unstable patients) unmasks shock (BP 58/36, HR 120).
 - Immediate use of pressors (Norepinephrine), large fluid bolus.
 - Invasive monitoring, central access established
 - CVP 12, BP 90/60, HR 120. Now SaO_2 has dropped to 92%
- \Rightarrow GEM aBg: pH 7.06, pCO_2 42, pO_2 278, BE -15, HCO_3^- 12, Lac 6.2, Hb 10.5

Case 2 Continued

- Start surgery; global diffuse oozing. The liver looks cirrhotic. A large duodenal ulcer is identified and oversewn.
- The surgeon suggests factor transfusion therapy
 - ? What products
 - ? What dose
 - ? When available
- \rightarrow Options:
 - 1) Empirical (shotgun, usual approach: 2-4 U FFP, 1 PU plts)
 - 2) Textbook: repeat labs, identify defect + correct
 - 3) Science fiction: Dose of rFVIIa or "Beriplex" prothrombin complex concentrate
- ❑ Option 1 is chosen after sending repeat coags.
- ❑ Clinical improvement
- ❑ PLT count comes back as 90 K - essentially unchanged
- ❑ Successful completion of surgery, to TSI intubated

Laboratory Related Aspects of Case 2

- Intraoperative assessment of patient not possible without lab data
- Cirrhosis suggests aggressive monitoring of hepatic synthetic function (to include PT)
- Baseline thrombocytopenia is consistent with portal hypertension, splenomegaly
- Erroneous reading of pulse-oximeter likely due to vasoconstrictor use, can only be confirmed by aBg
- Tracking and correction of acid-base status important for pressor effectiveness, cardiac contractility, coagulation
- Rapid information (i.e. POCT) has significant impact on management, maybe outcome

Reference Lab vs POCT

Questions:

- 1) Can a reference lab be as fast as POCT?
- 2) If so, would anesthesia providers have a preference?
- 3) With so many tests available in I-Stat format, are reference labs becoming obsolete?
- 4) Are results always needed "yesterday" in the OR?
- 5) Are there laboratory tests that should yet be developed?

Can a Reference Lab Be as Fast as POCT?

- “Not quite, but close”
- Example: “Stat PT” (no INR), approx 20 minutes vs > 45 minutes for full PT/INR.
- The Lab is not the only issue: Specimen transport, labeling verification and administrative handling can cause delays.
- A protocol for test result communication must exist.
- Clear and intense communication must identify specimen as “really stat”.
Causes of delays:
 - Government red tape (Clinical Laboratory Impediment Act)
 - Degree of lab utilization (very busy?)
 - Entering the specimen in the queue
 - Insufficient or incorrectly sent specimen

Regarding the other Questions

- 2) Anesthesiologists are control freaks – labs capabilities at the fingertips are the ideal
- 3) Nothing can replace the main laboratory - recent re-expansion of the “stat-lab” proves the point
- 4) The usual scenario in the OR is one of rapid events in flux. So yes: we need all of the results yesterday
- 5) Want to be a millionaire **and** win the Nobel Prize: Find a rapidly repeatable, POCT compatible test for measuring circulating blood volume. (And there would be others)

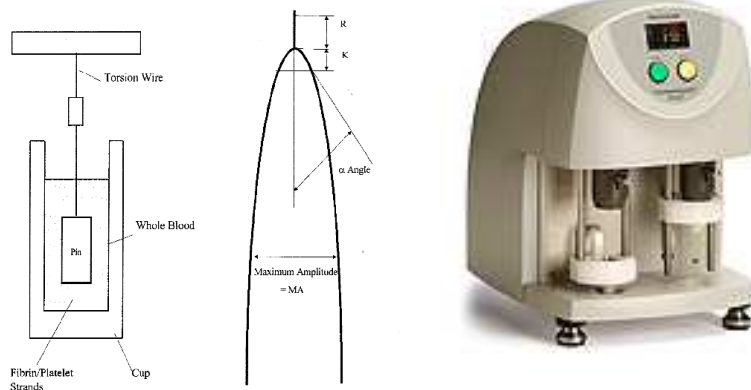
POCT

- Fast, but:
- Expensive
- Immediate specimen processing essential
- Trained personnel required (1 FTE for a full suite of tests)
- Equipment breakdowns not unusual
- Result dissemination usually not automatic
- Test reliability not always guaranteed
- Proper specimen procurement essential
- Range of tests limited – still need a reference lab!
- In the end: We are lazy enough to avoid extra effort if it is not necessary!
- Example: In the “old days” we had access to an “anesthesia OR profile” abg – everything the GEM does minus HCT/Lactate/Glu – turn-around time , 15 min.

Coagulation POCT's

- ACT (Activated Clotting Time)
 - Strictly for following heparinization
 - High dose heparin mode usually needed in the OR
- PT
- TEG (Thrombelastography)
 - Used in many major centers
 - Has been credited with improved management of coagulopathies
 - Measures whole blood coagulation and clot lysis
 - At least two systems exist (Rotem vs Haemoscope)
 - Normal test takes at least 45 minutes but
 - Clot acceleration with celite or thrombin is possible
 - Heparinase reagent vessels permit neutralization of heparin

TEG



Perioperative Medicine

- The need for laboratory testing does not end with the operation
- ➔ Frequent situations in the Post Anesthesia Care Unit include:
 - Diabetes
 - Hypotension without obvious cause
 - Hypoxia / hypoventilation
 - Suspected anemia
 - Arrhythmias
 - Cardiac event
 - Coagulation disturbance
 - Mental status changes
 - Calcium levels after parathyroidectomy

Transition from Acute to Chronic Care

- Interventions in the perioperative period are intensive and short term
- Transition to long term therapy starts or resumes after PACU
- Laboratory testing continues into the postoperative period
- Examples :
 - CK-MB, sequential Trop 1 testing
 - Blood glucose management
 - Sequential HCT
 - Interval cBc w diff for infectious processes
 - Anticoagulation monitoring
 - Organofunction monitoring (creatinine, hepatic synthetic function)

Conclusion

- The laboratory provides an extended view into acute physiological changes
- Little medicolegal consensus on preoperative testing
- Potentially substantial impact of lab results on anesthetic technique
- Lab data are critically important for intraoperative physiological management
- Speed is key – the more unstable the situation, the faster we need results
- POCT vs main lab – speed, reliability, affordability determine which modality
- Result dissemination is still the best when the main lab is on the case
- The laboratory world keeps improving at a fantastic pace!

- **Thank you all very much!!** (We would be helpless without you)